

CHEMICAL-PHYSICAL AND BIOLOGICAL ASSESSMENT OF WATER QUALITY IN THE CUYAHOGA RIVER (1973-1974)¹

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For the period of 1973-74 the concentrations of cadmium, chromium, nickel, zinc, nitrate-nitrogen, filtrable residue, hydrogen ions and water temperatures generally were satisfactory for most indigenous aquatic life and usually conformed to allowable limits of Ohio Water Quality Standards (Ohio WQS). Maximum levels of lead (0.1 mg/l) in the Brecksville area were unacceptable for many forms of aquatic life and exceeded allowable limits of Ohio WQS. During this survey dissolved oxygen (D.O.) concentrations always exceeded 6 mg/l at all sampling stations but, U.S. Geological Survey automatic D.O. monitors below Akron indicated that D.O. in this region sometimes dropped below 2 mg/l during the summer. Ammonia-nitrogen concentrations ranged from 0.1 mg/l in up-

stream areas to as much as 7.1 mg/l between Akron and Brecksville.

The density of fecal coliform bacteria averaged approximately 130/100 ml at Hiram Rapids, but increased markedly below Akron to more than 10,000/100 ml. The benthic macro-invertebrate community at Hiram Rapids was indicative of a relatively clean-water area consisting of 60 percent pollution-sensitive organisms including a few stoneflies, mayflies, caddisflies, and certain chironomids. The proportion of pollution-tolerant organisms gradually increased in downstream order accounting for more than 90 percent of the benthic invertebrate community between Akron and Independence. Approximately 155 taxa of benthic macro-invertebrates were identified from the river. Of this total 106-, 74-, 44-, 25-, 39-, and 30 taxa were found in downstream order at Hiram Rapids, Standing Rock Cemetery below Lake Rockwell, Old Portage, Boston Mills, Brecksville, and Independence respectively.

The purpose of this study was to evaluate water quality of the Cuyahoga River in relation to State of Ohio water quality standards (Ohio Env. Prot. Agency, 1973) and in relation to well-established criteria for sustaining desirable associations of aquatic life in flowing waters (Nat. Tech. Adv. Comm., 1968; U.S. Env. Prot. Agency, 1973). Selected chemical-physical and biological indexes of water quality were determined monthly for one year (Oct 1973-Sep 1974) at seven locations along the river. Chemical-physical measures of water quality included analyses of the concentration of dissolved oxygen, hydrogen ions (pH), nitrate-nitrogen, ammonia-nitrogen, total inorganic phosphates, filtrable residues,

the heavy metals, lead, cadmium, chromium, nickel, and zinc, and measurements of water temperatures. Biological measures of water quality included quantitative analyses of the composition of benthic macro-invertebrate communities and estimates of the density of fecal coliform bacteria. Periphyton, aquatic vascular plants, fish, and terrestrial vegetation adjacent to the river also were analyzed, but the results of these studies are not included in this report.

STUDY AREA

The Cuyahoga River is a relatively small tributary of Lake Erie located in heavily populated and industrialized northeastern Ohio (fig. 1). Arising in two major branches only 22 kilometers from Lake Erie, the Cuyahoga River

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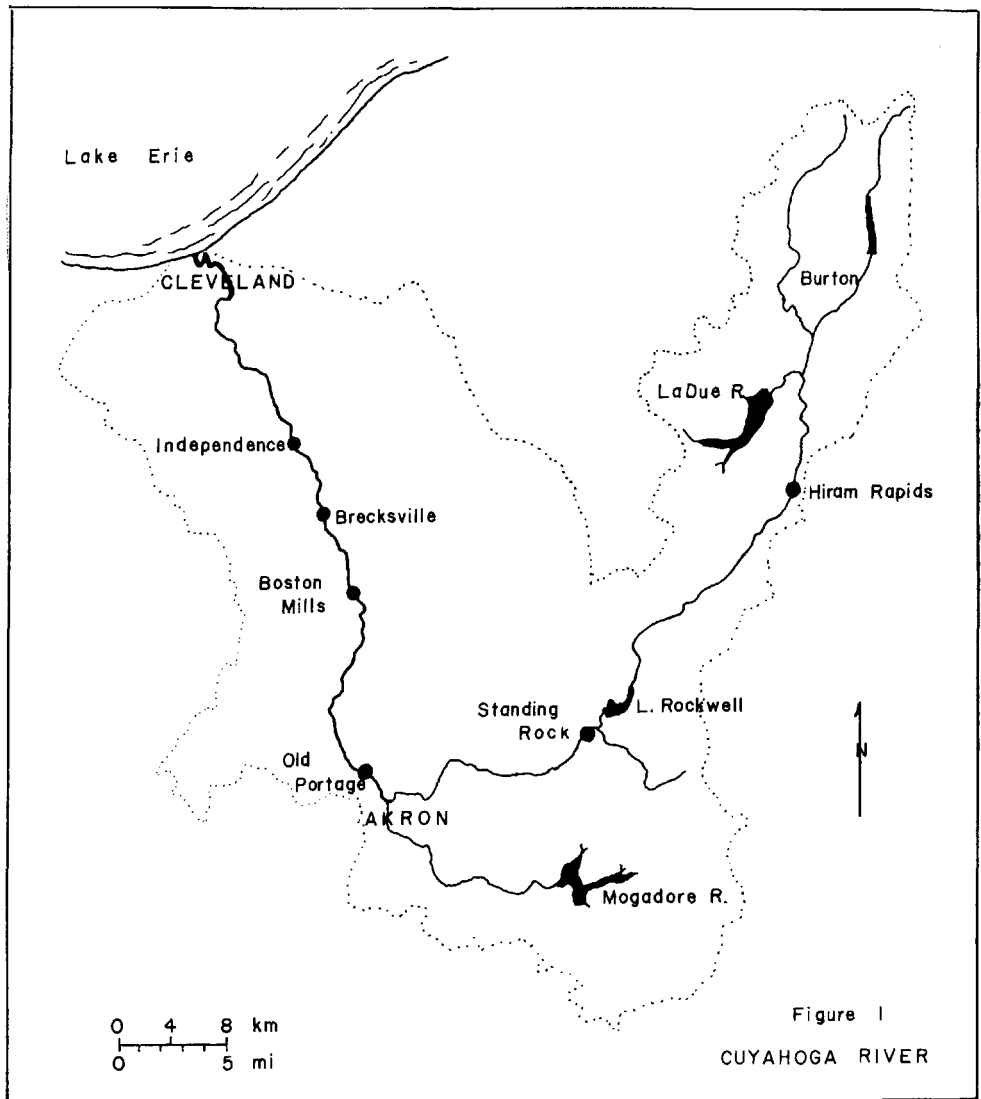


FIGURE 1. Map of the Cuyahoga River showing locations of water quality sampling stations. Sampling locations in up-stream order include Independence (km 20), Brecksville (km 31.8), Boston Mills (km 43), Old Portage (km 65), Standing Rock Cemetery (km 89), and Hiram Rapids (km 120).

flows southward away from the lake for approximately 90 kilometers, then turns abruptly northward for another 70 kilometers where it enters Lake Erie at Cleveland. The long-term average discharge near the mouth is approximately 800 cubic feet (22.6 m³/sec.) The unusual U-shape of the river is the result of complex glacial activity that ended in north-

eastern Ohio approximately 10,000 years ago (Rau, 1968).

The Cuyahoga River watershed contains approximately 2,081 km² and is extensively modified for residential and industrial purposes. The upper third of the basin is least modified for these purposes and contains numerous glacial lakes, bogs, and extensive marshy areas

adjacent to the main stream channel. Much of this area is used for recreational activities, especially fishing and canoeing, and as a public water supply for the City of Akron. Two large reservoirs, LaDue and East Branch, located along the upper watershed boundary provide storage capacity and regulate flow into a third reservoir, Lake Rockwell, located on the main river channel approximately 70 kilometers downstream. Under the Ohio Scenic Rivers Act of 1968, the Ohio Department of Natural Resources has designated approximately 40 km of the upper Cuyahoga River a "Scenic River," thereby ensuring a substantial degree of control over the quality of discharges to the river and over landscape modifications that can be made along the river.

From Lake Rockwell, the City of Akron withdraws approximately 45 million gallons ($1.7 \times 10^5 \text{ m}^3$) per day of water for domestic and industrial uses. Most of this water is returned to the river below Akron at the city's wastewater treatment plant. Between Lake Rockwell and Akron, the Cuyahoga River drops sharply through an area that originally contained numerous cascades and small waterfalls. The construction of several impoundments in the region, however, has greatly modified the original flow patterns. The watershed in this region is extensively modified for residential, industrial, commercial, and transportation purposes. Potential sources of pollution, especially from combined stormwater-sanitary sewer overflows and industrial sources, are numerous and widespread throughout the region. The Little Cuyahoga River which enters the Cuyahoga River in Akron is a major source of pollution. In addition to industrial wastes and sewer overflows the Little Cuyahoga River receives pollutants from surface drainage from residential, commercial, and industrial areas as well as streets, highways, and parking lots.

From Akron to Cleveland the Cuyahoga River flows through a scenic region that is considerably less modified than the metropolitan areas and contains numerous sites of historical and recreational interest. Effluent from the Akron wastewater treatment plant and moderately polluted waters of several tribu-

taries enter this region greatly reducing the recreational potential of the river. The recently created Cuyahoga Valley National Recreation Area will occupy a large portion of the watershed between Akron and Cleveland.

The lower 20 kilometers of the Cuyahoga River is surrounded by the City of Cleveland and neighboring municipalities. The watershed adjacent to the river is heavily used for residential, commercial, industrial, and transportation purposes. Potential sources of pollution from sewage treatment plants, combined stormwater-sanitary sewer overflows, urban surface drainage, soil erosion, and industrial facilities are numerous and widespread throughout this region. The last 10 kilometers of the Cuyahoga River is extensively modified for industrial purposes and as a navigation channel for commercial cargo vessels. The variety of uses that can be made of the river in this region is severely limited and its suitability for supporting well-balanced communities of aquatic organisms is greatly impaired (U.S. Army Engineers, 1971).

METHODS

Sampling stations along the Cuyahoga River were established at (1) Hiram Rapids, (2) Standing Rock Cemetery near Kent, (3) Old Portage below Akron, (4) Boston Mills near Boston Mills Road, (5) Brecksville near Route 82, and (6) Independence near Rockside Road (Fig. 1). The Brecksville station consisted of two widely different aquatic environments:—an impoundment for diverting water to the Ohio Canal and a high-velocity riffle area below the diversion dam. Data from these two areas were analyzed separately.

Selected chemical-physical and biological water quality analyses were made monthly at each station from October 1973 to September 1974. Chemical-physical analyses included quantitative determinations for dissolved oxygen, hydrogen ions, ammonia-nitrogen, nitrate-nitrogen, total inorganic phosphate, filtrable residue, the heavy metals, lead, cadmium, chromium, nickel, and zinc, and water temperature. These analyses were performed according to procedures recommended in the thirteenth edition of *Standard Methods for the Examination of Water and Wastewater* (Am. Pub. Health Ass'n., 1971). A Perkin-Elmer model 303 Atomic Absorption Spectrophotometer was used to determine the concentrations of heavy metals. These analyses were performed by the Geochemical Laboratory, Department of Geology, The University of Akron. Filterable residues were estimated from specific conductance values.

The density of fecal coliform bacteria was estimated according to membrane filter procedures as recommended in *Standard Methods* (Am. Pub. Health Ass'n., 1971). The major taxa and relative abundance of benthic macro-invertebrates were determined monthly at each station from quantitative samples of the benthic invertebrate communities. Major habitats were sampled with a modified shovel sampler to depths of 15–20 centimeters. Each sampling unit covered approximately .05 square meter. Random samples were taken from a stratified sampling area that consisted of a shore area, a pool, and a riffle at each location (Elliott, 1971). The total area sampled at each station ranged from 0.1 to 0.2 m², the largest samples being taken from stations with the greatest variety of organisms. The organisms were separated from most of the sediments with a No. 30 U.S. standard soil sieve and transported to the laboratory.

Immediately upon returning to the laboratory the animals were hand-picked while still alive from the residual sediments and debris. The organisms were preserved in 70% ethanol, and at a later date identified and enumerated. Most organisms were identified by taxonomic keys in *Fresh-Water Invertebrates of the United States* (Pennak, 1953), *Fresh-Water Biology* (Edmonson, 1959), or *Aquatic Insects of California* (Usinger, 1956).

RESULTS AND DISCUSSION

Selected Chemical-Physical Water Quality Parameters

Dissolved oxygen. During this survey dissolved oxygen concentrations in all areas always exceeded 6 mg/l, well above the minimum allowable levels of the Ohio water quality standards (Ohio Env. Prot. Agency, 1973). But these values give

an incorrect impression of dissolved oxygen regimes below Akron. The frequency of analyzing for dissolved oxygen in this region proved to be much too low to adequately describe the highly variable dissolved oxygen conditions. Measurements from automatic dissolved oxygen monitors at Independence and Old Portage show that during the summer of 1974 dissolved oxygen levels frequently fell below 4 mg/l and sometimes dropped below 2 mg/l (U.S. Geological Survey, 1973, 1974). Such low concentrations of dissolved oxygen even for short periods of time undoubtedly are quite harmful to aquatic life in the region (McKee and Wolf, 1963; Nat. Tech. Adv. Comm., 1968; U.S. Env. Prot. Agency, 1973). Low levels of dissolved oxygen also may intensify the damage to aquatic communities from toxic materials such as ammonia which are excessive in the river between Akron and Cleveland (McKee and Wolf, 1963).

Ammonia-Nitrogen. The maximum, minimum, and mean concentrations of ammonia-nitrogen in the Cuyahoga River are shown in figure 2. In the river above Kent, the levels of ammonia nitrogen were relatively low and never exceeded concentrations toxic to most aquatic life (McKee and Wolf, 1963; Nat. Tech. Adv. Comm., 1968; U.S. Env. Prot. Agency, 1973). Below Akron, however, the levels of ammonia-nitrogen

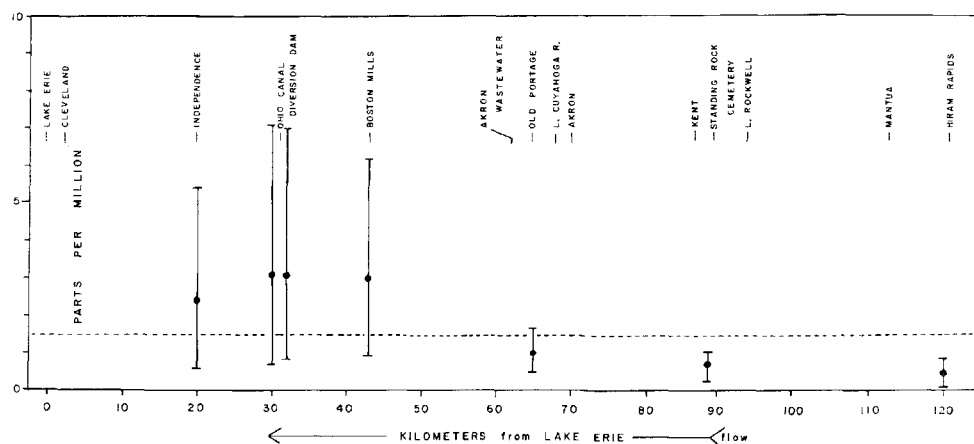


FIGURE 2. Ammonia-nitrogen profile of the Cuyahoga River. Maximum, minimum, and mean concentrations of ammonia-nitrogen are indicated on the solid vertical lines. Mean values are based on 12 consecutive samples taken monthly between October 15, 1973 and September 5, 1974.

increased considerably, usually exceeding levels safe for many aquatic organisms and exceeding allowable limits of the Ohio water quality standards. Ammonia-nitrogen levels were especially high below the Akron wastewater treatment facility, and persisted downstream for more than 30 kilometers. These relatively high levels of ammonia, especially in combination with periodic reduction of dissolved oxygen concentrations, probably are the major cause of the elimination of so many species of aquatic life between Akron and Cleveland. The toxic effects of these conditions have been especially damaging to the permanent fish communities which have been eliminated from most of the region.

Nitrate-Nitrogen. Nitrate-nitrogen concentrations along the Cuyahoga River ranged from .35 to 3.8 mg/liter (table 1). Mean concentrations were lowest at Hiram Rapids (.7 mg/l) and highest in the Brecksville-Independence (2.1-2.2 mg/l) region. Even the highest levels

along the river appear satisfactory for most aquatic life and all other water uses.

Total inorganic phosphate. The maximum, minimum, and mean concentrations of phosphates in the Cuyahoga River are shown in table 1. Mean phosphate concentrations were least at Hiram Rapids (.33 mg/l), increasing slightly downstream to Old Portage (.73 mg/l), then increasing to moderately high levels below the Akron wastewater treatment facility (1.24-1.33 mg/l). The State of Ohio has not set limits of concentration for total phosphates in flowing waters. While total phosphorus is of great importance in water supplies, the allowable concentrations depend upon many factors including other chemical constituents of the water, the nature of the bottom materials, temperature and the desired water use. As a general guideline the concentration of total phosphorus should not exceed 0.1 mg/l in flowing streams (Nat. Tech. Adv. Comm., 1968; U.S. Env. Prot. Agency,

TABLE 1

Selected chemical-physical water quality data for six locations along the Cuyahoga River. The maximum, minimum and mean values for twelve consecutive monthly samples are shown. Only maximum levels are shown for heavy metals. Sampling began in October 1973 and ended in September 1974.

	Station					
	(1) Hiram Rapids	(2) Standing Rock	(3) Old Portage	(4) Boston Mills	(5) Brecksville	(6) Independence
Heavy metals (mg/l)						
Lead (max)	<.1	<.1	<.1	<.1	.1	<.1
Cadmium (max)	<.02	<.02	<.02	<.02	.02	<.02
Chromium (max)	<.1	<.1	<.1	<.1	<.1	<.1
Nickel (max)	<.1	<.1	<.1	<.1	<.1	<.1
Zinc (max)	.07	.08	.06	.12	.11	.10
Nitrate-Nitrogen (mg/l)						
max.	1.3	1.7	3.1	3.1	3.5	3.5
min.	.3	.3	.5	.8	.9	1.0
mean	.7	1.0	1.3	1.8	2.1	2.2
Hydrogen ion (pH)						
max.	8.3	8.5	8.7	8.5	8.5	8.5
min.	7.1	7.9	8.1	8.0	7.4	7.5
mean	7.8	8.3	8.4	8.2	8.0	8.0
Filtrable residue (mg/l)						
max.	192	225	372	660	930	638
min.	119	129	185	216	210	247
mean	154	156	271	366	398	360
Phosphate						
total inorganic (mg/l)						
max.	1.10	2.10	2.80	1.90	3.40	3.60
min.	.13	.15	.22	.21	.11	.12
mean	.33	.66	.73	1.24	1.13	1.33

1973). Levels in excess of this quantity may cause undesirable growths of algae and other aquatic plants. Despite relatively high levels of phosphates in the lower Cuyahoga River nuisance growths of aquatic plants were not observed.

Filtrable residue (dissolved solids). Filtrable residue concentrations along the Cuyahoga River ranged from 119 to 930 mg/l (table 1). Mean values were lowest at Hiram Rapids (154 mg/l) and at Standing Rock Cemetery (156 mg/l) and never exceeded allowable limits of the Ohio WQS. Below Akron, however, filtrable residue concentrations increased markedly to 2-3 times higher than in upstream areas, but despite this increase allowable limits of the Ohio WQS were not violated.

Heavy metals (Pb, Cd, Cr, Ni, Zn). Maximum concentrations of the heavy metals, lead, cadmium, chromium, nickel, and zinc in the Cuyahoga River are shown in table 1. The maximum levels of chromium (<.1 mg/l) and zinc (.12 mg/l) are acceptable for most aquatic life (U.S. Env. Prot. Agency, 1973) and do not exceed allowable limits of Ohio WQS (Ohio Env. Prot. Agency, 1973). The maximum concentration of lead (.1 mg/l) occurred in the Brecksville area and does not conform to allowable limits of the Ohio WQS. Lead concentrations in other sections of the river probably are acceptable, however an exact assessment

cannot be made because allowable levels are less than the minimum quantities detectable with the instrumental methods utilized. The concentrations of nickel (<.1 mg/l) probably are acceptable for aquatic life and other water uses in all areas of the river (U.S. Env. Prot. Agency, 1973). Allowable limits for nickel are not specified in Ohio WQS. The concentrations of cadmium in the Cuyahoga River probably are acceptable for aquatic life in all locations. In the Brecksville area cadmium levels occasionally, only slightly, exceed allowable limits of Ohio WQS, however, the levels are acceptable for aquatic life according to proposed U.S. Environmental Protection Agency water quality criteria (1973).

Hydrogen ions (pH). Hydrogen ion concentrations along the Cuyahoga River ranged between pH 7.1 and 8.7 never exceeding allowable limits of the Ohio WQS (table 1). At Hiram Rapids pH values were slightly lower than downstream areas because of relatively larger proportions of acidic-neutral waters from upstream bogs and marshes. After a slight increase in pH below Lake Rockwell there was very little difference in pH values along the remainder of the river.

Water temperatures. Maximum monthly water temperatures along the Cuyahoga River are shown in table 2. Temperatures do not exceed allowable

TABLE 2
Water temperatures (°C) for six locations along the Cuyahoga River, 1973-74.

Date	Station					
	(1) Hiram Rapids	(2) Standing Rock	(3) Old Portage	(4) Boston Mills	(5) Brecksville	(6) Independence
Oct/73	16	16	21	20	18	20
Nov/73	10	9.5	13	13	11.5	11
Dec/73	1	3.2	8	4	4	3
Jan/74	0.5	1.5	6.5	5	4.5	3.5
Feb/74	0	1.6	5	6	6	4.5
Mar/74	1	2	7	7.5	7.5	8
Apr/74	9.5	10.5	13.5	12.5	12.5	13.5
May/74	18.5	19	22	20	20	21
Jun/74	19	19	23	20	20	20
Jul/74	23	23	25	25	25	25
Aug/74	21	22	24	23.5	23	22
Sep/74	17	17.5	20	18	18	18

limits of Ohio WQS for any of the sampling areas. At Old Portage water temperatures were elevated several degrees above normal because of heat additions from the Ohio Edison Company power plant in Cuyahoga Falls, however, the values are within allowable limits of Ohio WQS. Water temperatures throughout most of the Cuyahoga River are undoubtedly several degrees higher than before the region was settled and before the vegetation that shaded the streams was cleared from the watershed. These higher temperatures probably have had considerable impact on aquatic communities in the river, however, the nature of these changes is not known precisely because of inadequate records from presettlement days.

Selected Biological Water Quality Parameters

Fecal coliform bacteria. The concentrations of fecal coliform bacteria along the Cuyahoga River are shown in figure 3. The black squares in this figure indicate the geometric mean number of organisms per 100 ml for twelve consecutive monthly samples. The presence of fecal coliform bacteria is indicative of

recent and possibly dangerous fecal contamination. The density of fecal coliform bacteria is highly correlated with the density of human pathogenic viruses and human pathogenic bacteria (U.S. Env. Prot. Agency, 1973).

At Hiram Rapids the number of fecal coliform bacteria averaged approximately 130/100 ml, well within acceptable limits for all water uses (Ohio Env. Prot. Agency, 1973). At Standing Rock Cemetery the number of fecal coliform organisms increased to approximately 1000/100 ml exceeding Ohio WQS allowable numbers of 200/100 ml. From Akron to Independence the number of fecal coliform bacteria increased dramatically, averaging between 4,000 and 11,000/100 ml. The major source of these organisms is probably inadequately treated or untreated sewage from diffuse sources and from wastewater treatment plants in the area. Other possible sources of fecal coliform bacteria are the combined storm-water-sanitary sewer overflows from metropolitan Akron and neighboring municipalities.

Benthic macroinvertebrates. The major-group percent composition of benthic macroinvertebrate communities from

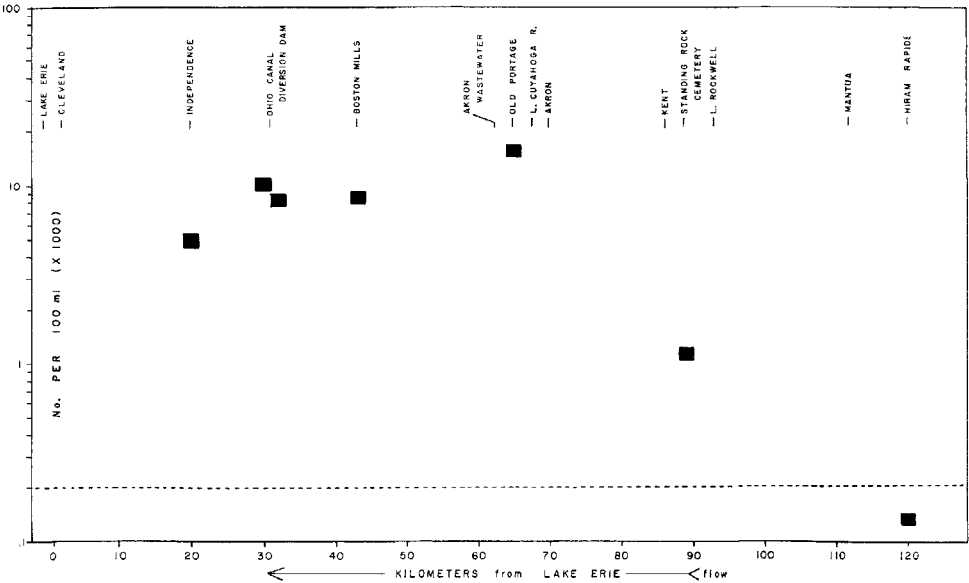


FIGURE 3. Fecal coliform bacteria profile of the Cuyahoga River. Black squares indicate geometric mean values of 12 samples taken monthly between October 15, 1973 and September 5, 1974.

seven locations along the Cuyahoga River is shown in figure 4. These percentages are based on the number of individuals from major taxonomic groups of benthic organisms including Annelida, Mollusca, Diptera, Coleoptera, Ephemeroptera, Hemiptera, Megaloptera, Odonata, Plecoptera, Trichoptera, Turbellaria, and non-insect arthropods. Each bar of the river profile in Figure 4 shows the mean community composition of twelve samples taken monthly between October 1973 and September 1974.

The bar to the far right of figure 4 labelled "ref" shows the percentage composition of a benthic invertebrate community from Deer Creek, an exceptionally high-quality tributary of the Scioto River in central Ohio (Olive and Smith, 1975). The composition of this benthic community is shown for comparative purposes. Proportions for each major

group represented in this bar are the means of eighteen samples taken over a 3-year period including samples from each season. The major-group composition of benthic communities from other high-quality waterways would be quite similar to the composition of this reference community (Hynes, 1960; Gauvin, 1973). Minor differences in composition would be expected, of course, and seasonal variations would occur, but in general the same basic compositional patterns would be evident from similar habitats in unpolluted streams regardless of geographic locations.

Black bars and checkered bars in figure 4 represent organic pollution-tolerant tubificids and the pulmonate snail, *Physa*, respectively. Shaded bars represent dipterans, mostly chironomids, many of which are pollution-tolerant or intermediately tolerant of organic pollution.

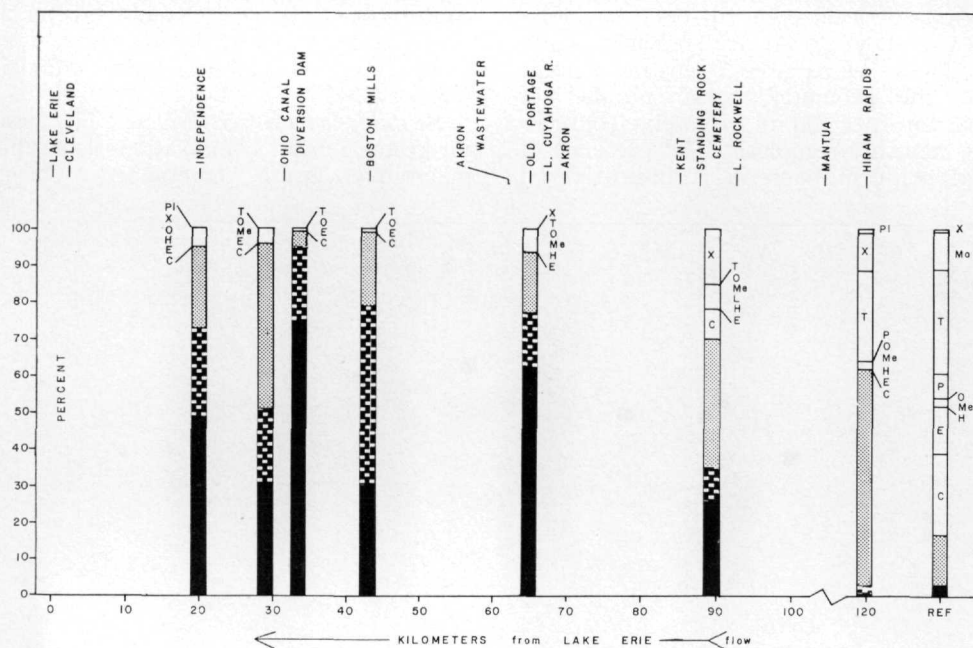


FIGURE 4. Benthic macroinvertebrate community profile of the Cuyahoga River. The major-group composition (%) is shown for seven locations along the river. Percentages are based on the number of individuals from major taxonomic groups. Mean percentage values are shown for 12 consecutive samples taken monthly between October 15, 1973 and September 5, 1974. Code: black bars = annelids, checkered bars = pulmonate snails, shaded bars = Diptera, C = Coleoptera, E = Ephemeroptera, H = Hemiptera, Me = Megaloptera, O = Odonata, P = Plecoptera, T = Trichoptera, Mo = Mollusca, Pl = Platyhelminthes, X = non-insect arthropods, REF = reference community of benthic invertebrates from a high-quality tributary of the Scioto River (Olive and Smith, 1975).

Many dipterans also are tolerant of inorganic silt pollution. Clear bars represent pollution-sensitive organisms such as riffle beetles, mayflies, stoneflies, caddisflies, fishflies, alderflies, true bugs, unionid clams, and gill-bearing snails (Weber, 1973).

Examination of figure 4 indicates that the composition of most benthic macro-invertebrate communities along the Cuyahoga River differs markedly from the Deer Creek reference community. The differences are most striking below Akron where in most areas pollution-tolerant organisms usually account for more than 90% of the benthic communities. Clear-water organisms seldom account for more than 5% of the benthic communities in this region and even these organisms may not have come from established populations, but rather have drifted into the area from less damaged upstream sections.

Above the Akron-Kent area at Standing Rock Cemetery, the composition of the benthic invertebrate community resembles the reference community somewhat more closely. In this region the benthic community consists of approximately 50% pollution-sensitive and facultative organisms and 50% pollution-tolerant organisms. Despite this improvement in composition, the benthic community still reflects moderately adverse conditions resulting most probably from excessive inorganic and organic siltation.

The composition of the benthic community at Hiram Rapids indicates a relatively undamaged waterway. Pollution-sensitive animals account for approximately 60% of the community and intermediately-tolerant organisms or organisms of uncertain status account for most of the remainder. Less than 10% of the community consists of pollution-tolerant organisms. Overall the resemblance between benthic communities at Hiram Rapids and the Deer Creek reference station is much closer than the resemblance between other benthic communities along the Cuyahoga River and the reference station. Despite this close resemblance the proportion of chironomids at Hiram Rapids is unusually large. This situation probably

reflects moderate siltation of the stream-bed as a result of vegetation removal along the river, and septic tank drainage from numerous stream-side homes and cabins in the region.

The number of taxa, or preferably the number of species, of benthic invertebrates has been widely used as an index of water quality because benthic communities from high-quality waterways contain a large variety of species (Mackenthun, 1969). Species are eliminated from a community in proportion to the quantity and quality of stress placed upon it. Organisms least tolerant of the particular stress are eliminated first followed by the more tolerant species until only the most tolerant organisms remain. In the absence of predators and competitors the most tolerant species sometimes become extremely abundant. Under severely toxic conditions, however, even these organisms may be eliminated from the waterway.

The number of taxa comprising benthic macro-invertebrate communities along the Cuyahoga River is shown in figure 5. During the 12-month study period approximately 155 taxa were identified from the river. Of this total 106-, 74-, 44-, 25-, 39-, and 30 taxa were found at Hiram Rapids, Standing Rock Cemetery, Old Portage, Boston Mills, Brecksville, and Independence respectively. Relatively large monthly variations occurred in the number of taxa collected. For example, at Hiram Rapids as few as 19 taxa were taken in April and as many as 33 taxa collected in May. On the average only 27 percent of the total number of taxa known to occur at Hiram Rapids was collected during any one sampling event. Similar variations in results were evident at the remaining stations along the river.

The number of taxa found at Hiram Rapids is comparable to other undamaged or slightly damaged rivers in Ohio (Gaufin, 1958; Olive and Dambach, 1973; Olive and Smith, 1975) and other northern temperate regions (Hynes, 1960; Mackenthun, 1969; Gaufin, 1973; Roback, 1974). Downstream from Hiram Rapids, however, the variety of organisms decreased rapidly. At Standing Rock Cemetery the number of taxa was re-

duced to only 48 percent of the number from the entire river or approximately 70 percent of the number of taxa taken at Hiram Rapids. Between Akron and Cleveland the number of taxa was reduced to only 16-28 percent of the total number or 24-41 percent of the number of taxa collected at Hiram Rapids.

As shown in figure 5 seasonal variations were somewhat apparent in the number of taxa of benthic invertebrates collected in most areas along the Cuyahoga River. The largest number of taxa

generally was taken in the later summer, autumn and winter months because of newly hatched insect larvae and nymphs. The least number of taxa usually was taken in early spring as the immature organisms dispersed, died, or transformed into terrestrial adults. Turbulent water-flow during the spring also may have reduced the number of taxa through direct wash-out of organisms and through habitat destruction.

Acknowledgments. This report is a portion of an ecological study of the Cuyahoga River sup-

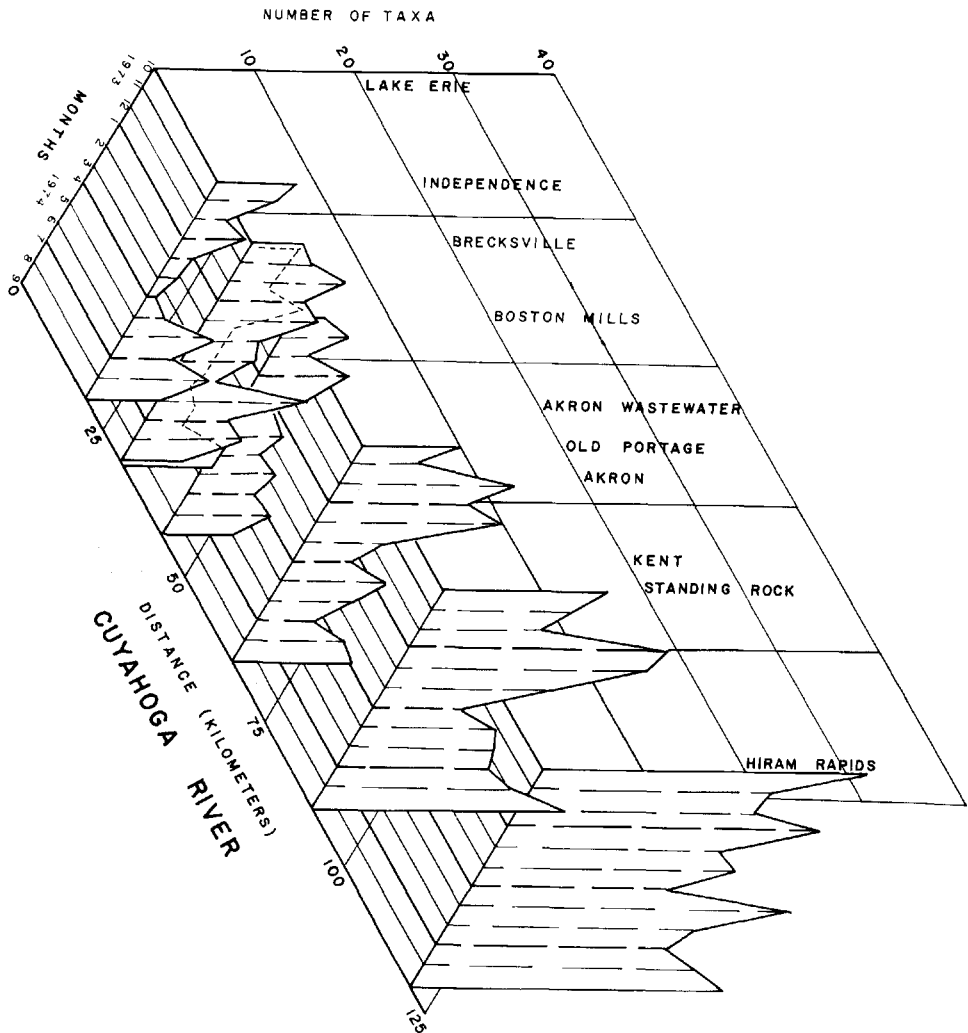


FIGURE 5. Profile of the number of taxa of benthic macroinvertebrates collected monthly along the Cuyahoga River. (Modified from an original drawing by Betty Cummings).

ported by the U. S. Army Engineer District, Buffalo, New York. Dr. Robert Corbett, the University of Akron, and Gary Dannemiller performed the atomic absorption spectrophotometric analyses of heavy metals. Students from the University of Akron assisted with field sampling and with numerous chemical-physical and biological water quality analyses. They were Jack Price, Sue Lauer, Felicia Tang, Michael Neag, Beverly Heath, Tom Danforth, Carol Hazlip, and Mimi Rudolph. Nanette Blohm and Mary Manderbach typed the manuscript.

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